

TECHNICAL REPORT

67-54-GP

AD 654789
AD

**GUIDE FOR ESTIMATING MAXIMUM ANCHOR
LOADS ON AIR-SUPPORTED STRUCTURES**

by

Thomas C. Strain

and

Ronald F. Tumeinski

RECEIVED

JUL 21 1967

CESTI

March 1967

JUL 16 1967

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760



General Equipment & Packaging Laboratory

Distribution of this report
is unlimited. Release to
CFSTI is authorized.

AD _____

TECHNICAL REPORT
67-54-GP

GUIDE FOR ESTIMATING MAXIMUM
ANCHOR LOADS ON AIR-SUPPORTED STRUCTURES

by

Thomas C. Strain
and
Ronald F. Tumeinski

Project No. 1M642101D503

March 1967

General Equipment & Packaging Laboratory
U. S. ARMY NATICK LABORATORIES
Natick, Massachusetts

FOREWORD

This report was prepared by the Shelters Division, General Equipment and Packaging Laboratory, U. S. Army Natick Laboratories, Natick, Mass. The work was performed under Exploratory Development Project 14642101D503, "Tents and Organization Field Equipment," Task 01, Studies in the Structural Mechanics of Tentage, Work Unit 003, Review of Design Manual.

Its contents are based on the technical data contained in the "Design Manual For Ground-Mounted, Air-Supported Structures," prepared by the Hayes International Corp. Birmingham, Alabama, for N Labs under contract DA19-129-AMC-129.

The intent of this report is to provide the design engineer with a complete, concise guide for planning the ground support and anchoring devices required for stabilizing air-supported structures.

The authors wish to acknowledge the guidance, encouragement and support of Mr. C. J. Monego of the Shelters Division in the preparation of this work.

EDWARD A. NEBESKY, Ph. D.
Acting Director
General Equipment & Packaging Laboratory

APPROVED:

DALE H. SIELING, Ph.D.
Scientific Director

W. M. MANTZ
Brigadier General, USA
Commanding

TABLE OF CONTENTS

	<u>Page</u>
List of Figures	iv
Symbols	v
Abstract	vi
1. Introduction	1
2. Anchor Load Calculations	2
a. Forces Creating Anchor Loads	2
b. Definition of Anchor Load Coefficients	8
c. Formulas for Calculating Anchor Loads	9
d. Sample Calculations	13

LIST OF FIGURES

	<u>Page</u>
1. Single-Wall, Spherical	3
2. Single-Wall, Cylindrical	3
3. Double-Wall, Cylindrical	3
4. Variation of Impact Pressure with Air Speed, Sea Level Standard Atmosphere	6
5. Impact Pressure Correction Factor, k_p , Variation with Altitude & Temperature	7
6. Variation of Anchor Load Coefficient with Shape (Spherical)	10
7. Variation of Base Anchor Load Coefficient with Shape	11
8. Variation of Guy Line Load Coefficient with Shape	12
9. Single-Wall Sphere	13
10. Single-Wall Cylinder	15
11. D-W Cylinder	17

SYMBOLS

A_f	Floor area, sq ft
A_p	Planform area (max. horizontal cross sectional area), sq ft
AL	Anchor Load, lbs
AL_e	Anchor load due to internal pressure, lbs
BL	Base anchor load, lbs
C_{AL}	Anchor load coefficient, single-wall
C_{BL}	Base anchor load coefficient, double-wall
C_{GL}	Guyline anchor load coefficient, double-wall
a	Reference length - tent diameter, ft
GL	Guyline anchor load, lb
h	Tent height, ft
l_h	Length of tent, ft
P_{AL}	Total anchor load, lbs
P_e	Shelter enclosure pressure, lb/sq ft
q	Dynamic (impact) pressure, lb/sq ft
r	Tent radius, ft
U	Velocity, ft/sec
W	Tent width, ft
ρ	Density of air, Slugs/cu ft

ABSTRACT

This report contains all the graphs, tables, mathematical formulas, and design data necessary to estimate the maximum loads on anchoring systems used with air-supported shelters subjected to winds up to 105 mph. The design data are presented in non-dimension coefficient form. Sample problems are included to illustrate the use of the data and their application to both single and double-wall structures.

GUIDE FOR ESTIMATING MAXIMUM ANCHOR LOADS ON AIR-SUPPORTED STRUCTURES

1. Introduction

In October 1950, a Design Manual for Spherical Air-Supported Radomes was published as Cornell Aeronautical Laboratory Report No. UB-664-D-1. After its publication, the radome was adopted as standard by the military on many ground-mounted radar installations. Hundreds were built and considerable experience with their design and operations had been gained in the field.

In March 1956, the Cornell Design Manual was revised to incorporate information accumulated since its original publication. This revised manual, is designated as: "Design Manual for Spherical Air-Supported Radomes (Revised) Report No. UB-909-D-2."

Air-supported shelters were being developed for the military, varying in shape from spherical radomes to cylindrical structures with spherical or flat ends. Although the spherically shaped radome had been subjected to aerodynamic testing, no studies were made for other shapes. The design of other configurations was based on fragmentary information available from various sources. The need for reliable design information was obvious.

To obtain aerodynamic data on flexible, cylindrical, air-supported structures, a limited wind tunnel study was conducted at the Massachusetts Institute of Technology on a one-tenth scale model of the Army's standard, tent, air-supported, single-wall, Nike-Hercules, above-ground launcher. As a result, a final report was prepared by Raffi J. Bicknell entitled, "Wind Tunnel Test on an Air-Supported Tent Model" Report No. 1024, Department of Aeronautics and Astronautics, Wright Brothers Wind Tunnel, MIT, June 1963.

Beginning in July 1963, the U.S. Army Natick Laboratories contracted a program with the Hayes International Corp. for extensive wind tunnel studies on spherical and cylindrical single-wall* structures and cylindrical double-wall** structures.

*Single-Wall - A flexible structure consisting of a single membrane usually in the shape of a sphere or cylinder. It is supported by a continuous flow of high volume, low pressure air enclosed between the membrane and mounting surface.

**Double-Wall - A flexible structure consisting of two membranes usually in the shape of a half cylinder. The two membranes form an envelope containing air, which resembles an air mattress bent into a "U" shape. The structure is supported by a flow of low volume, high-pressure air.

This program consisted of analytical and wind tunnel studies on 26 scale model air-supported structures. This contract resulted in a design manual entitled, "Design Manual for Ground-Mounted Air-Supported Structures." It provides design criteria to facilitate engineering of aerodynamically stable air-supported structures. Included in the design manual are data for estimating maximum anchor loads to be expected in winds up to 106mph. The contents of the present report are based on the data contained in the Hayes report. It is prepared for the convenience of engineers whose primary interest is the anchoring of military shelters.

2. Anchor Load Calculations

a. Forces Creating Anchor Loads

Fabric shelters subjected to winds of high velocity can experience aerodynamic forces of considerable magnitude. In order to estimate the magnitude of these forces, twenty six single and double-wall shelter models were tested in a wind tunnel with winds up to 105 miles per hour. The aerodynamic force data obtained, were reduced to non-dimensional coefficient form by dividing the force data by a reference area and the dynamic pressure.

Several very important facts should be emphasized at this time. The aerodynamic force data used here were maximum values so that the anchor loads calculated by techniques in this report will be maximum loads. The second fact is that no attempt has been made to ascertain the effect of wind gusts. The impact pressure used is for a wind of constant velocity.

The tent planform area A_p was selected as the reference area and is defined as the maximum cross sectional area in a horizontal plane. Planform areas are given by the following expressions for common tent types:

Sphere

$$A_p = \pi \left(\frac{W}{2} \right)^2$$

Cylinder with spherical ends:

$$A_p = \pi \left(\frac{W}{2} \right)^2 - W \left(1 - \frac{W}{h} \right)$$

Figures 1 through 3 are examples of air-supported structures.

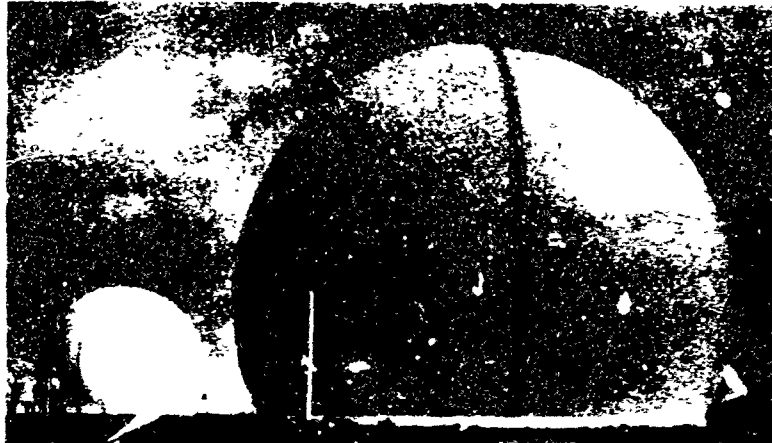


Figure 1. Single-Wall, Spherical

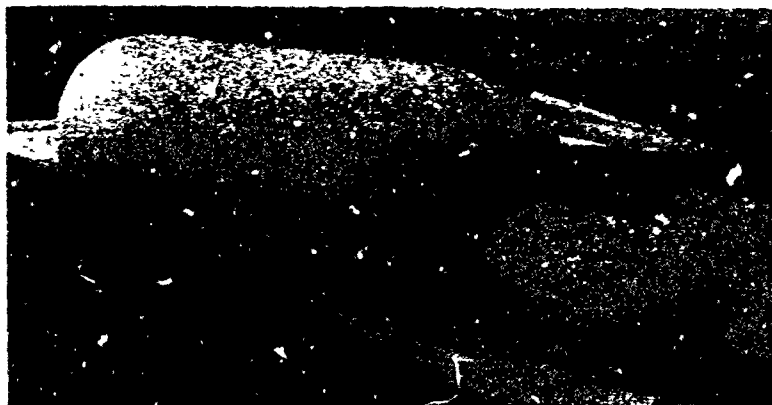


Figure 2. Single-Wall, Cylindrical

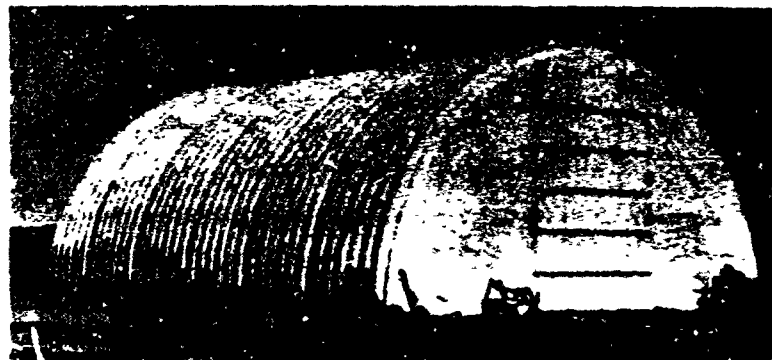


Figure 3. Double-Wall, Cylindrical

Cylinder with flat ends:

$$A_p = W l_h$$

where:

$$A_p = \text{planform area, sq ft}$$

$$W = \text{width of tent, ft}$$

$$l_h = \text{length of tent, ft}$$

The planform areas for tents with radii up to 80 feet are shown in Table I.

The dynamic pressure, q , due to wind velocity is defined by the following expression:

$$q = \frac{\rho U^2}{2}$$

where:

$$q = \text{dynamic pressure, lb/sq ft}$$

$$U = \text{wind velocity, ft/sec}$$

$$\rho = \text{density of air in (slugs/cu ft), } \frac{1 \text{ b} - \text{sec}^2}{\text{ft}^4}$$

$$= .00238 \text{ for a standard day at sea level}$$

The variation of impact pressure with wind speed at sea level and 59°F is shown in Figure 4. An impact pressure correction factor as a function of pressure altitude and temperature is shown in Figure 5.

In single wall shelters, the lift due to internal pressure must be added to the aerodynamic lift. The load on the anchors due to internal pressure can be calculated from the following expression:

$$AL_e = P_e A_f$$

$$AL_e = \text{anchor load due to internal pressure, lbs}$$

Table I
TENT PLANFORM AREA, A_p
SPHERICAL AND CYLINDRICAL TENTS WITH HEMISPHERICAL ENDS

Tent Radius r Ft.	Tent Planform Area, A_p , Sq. Ft.			
	Spherical	Cylindrical $1/2 = W/l_h$	Cylindrical $1/3 = W/l_h$	Cylindrical $1/4 = W/l_h$
10	314	714	1114	1514
12	452	1028	1604	2180
14	615	1399	2183	2967
16	804	1828	2852	3876
18	1017	2313	3609	4905
20	1256	2856	4456	6056
22	1520	3456	5392	7328
24	1809	4113	6417	8721
26	2123	4827	7531	10235
28	2463	5599	8735	11871
30	2827	6427	10027	13627
32	3216	7312	11409	15505
34	3631	8255	12879	17503
36	4071	9255	14439	19623
38	4536	10312	16088	21864
40	5026	11426	17826	24226
42	5541	12597	19653	26709
44	6082	13826	21570	29314
46	6647	15111	23575	32039
48	7238	16454	25670	34886
50	7853	17854	27854	37854
52	8494	19310	30126	40942
54	9160	20824	32488	44152
56	9852	22396	34940	47484
58	10568	24024	37480	50936
60	11309	25709	40109	54509
62	12076	27452	42828	58204
64	12868	29252	45636	62020
66	13684	31108	48532	65956
68	14526	33022	51518	70014
70	15393	34993	54593	74193
72	16286	37022	57758	78494
74	17203	39107	61011	82915
76	18145	41249	64353	87457
78	19113	43449	67785	92121
80	20106	45706	71306	96906

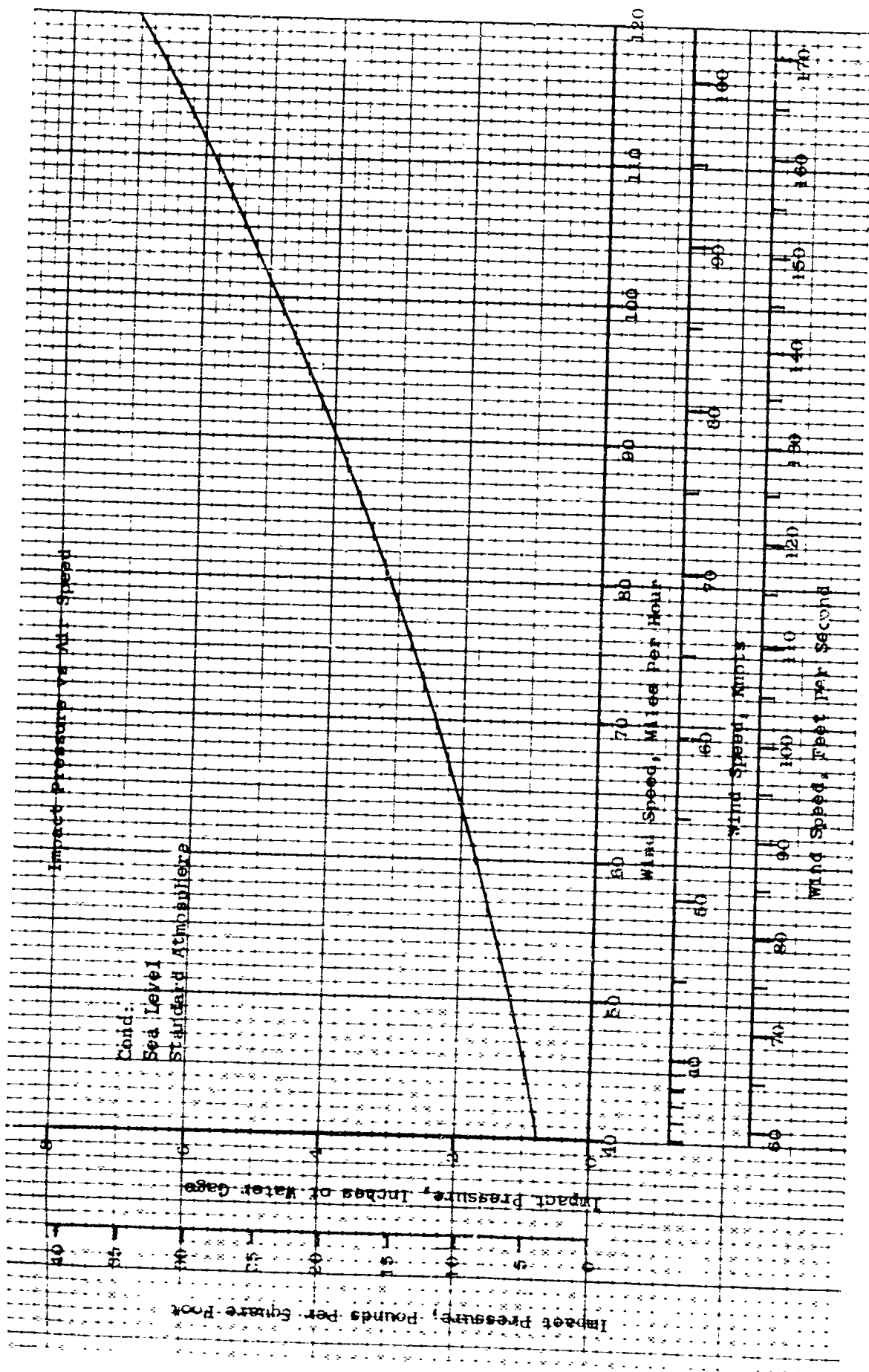


Figure 4. Variation of Impact Pressure with Air Speed, Sea Level Standard Atmosphere

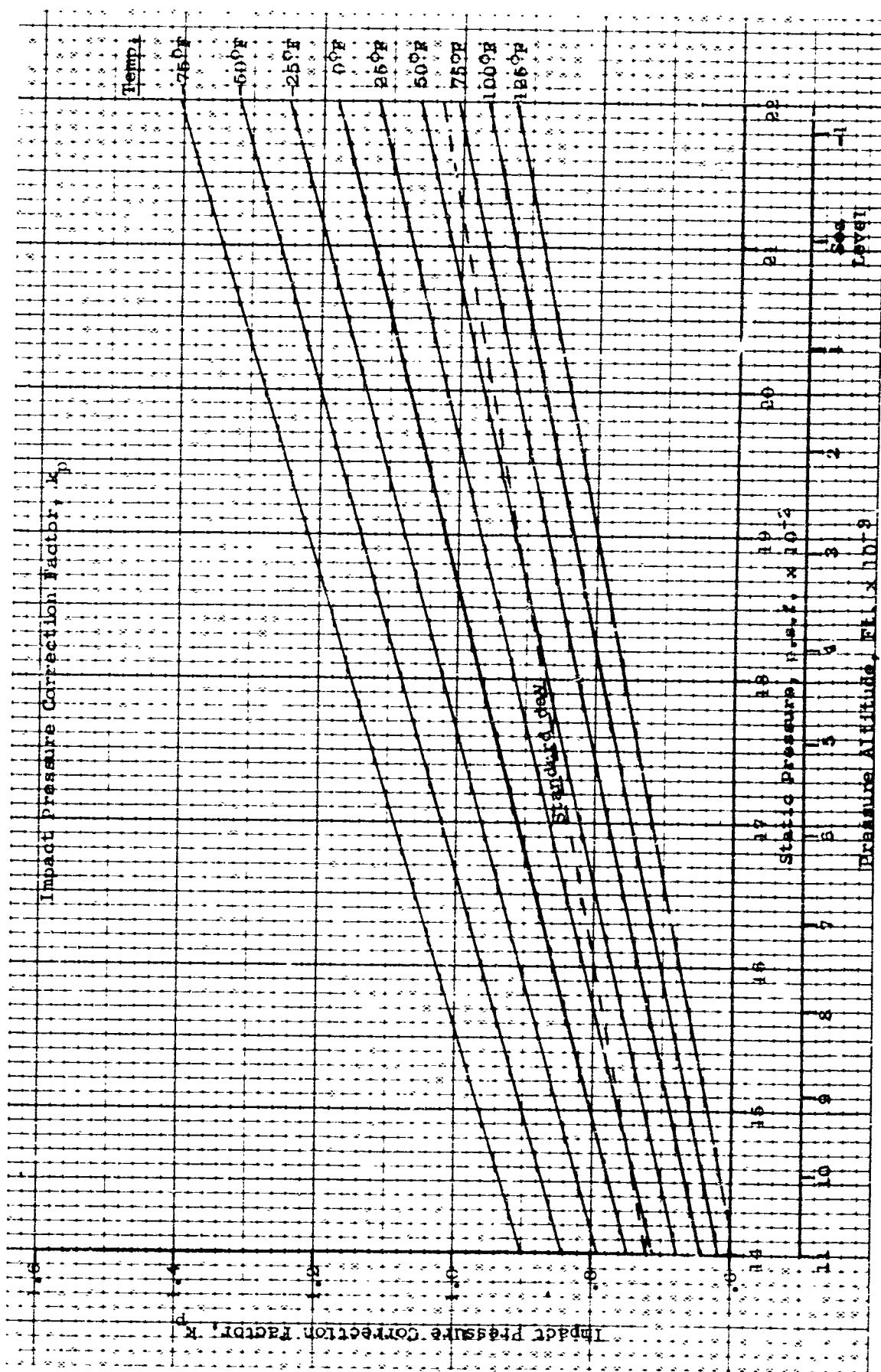


Figure 5. Impact Pressure Correction Factor, k_p , Variation with Altitude and Temperature

P_e = internal pressure, lbs/sq ft

A_f = floor area, sq ft

To summarize, the total force that must be resisted by the shelter anchoring system is created by the:

- (1) Aerodynamic load for double wall shelters
- (2) Aerodynamic load PLUS internal pressure for single wall shelters.

b. Definition of Anchor Load Coefficients

The general definition of an anchor load coefficient due to aerodynamic forces is:

$$C_{AL} = \frac{AL}{qA_p}$$

where:

AL = anchor load, lbs

C_{AL} = anchor load coefficient

In double wall shelters the anchor load is carried by anchors at the base of the shelter, as well as, by anchors securing the guy lines. The coefficients associated with these two loads are:

$$C_{BL} = \frac{BL}{qA_p}$$

$$C_{GL} = \frac{GL}{qA_p}$$

C_{BL} = Anchor load coefficient for base of shelters.

C_{GL} = Anchor load coefficient for guy lines.

BL = Anchor load on base, lbs.

GL = Anchor load on guy lines, lbs.

q = Dynamic (Impact) Pressure lbs/sq ft

Anchor load coefficients as a function of width/length and height/diameter ratios are plotted in Figures 6, 7 and 8.

c. Formulas for Calculating Anchor Loads

Using Figures 6, 7, and 8 it is a simple matter to estimate the maximum anchor load on an air supported structure. The problem resolves itself to geometry and substitution into formulas. The items of information required are:

Shelter geometry
Design wind speed
Enclosure pressure (single wall only)

(1) Single Wall Shelters

$$\text{Total Anchor Load } P_{AL} = C_{AL} q A_p + P_e A_f$$

(2) Double Wall Shelters

$$BL = C_{BL} q A_p$$

$$GL = C_{GL} q A_p$$

$$\text{Total Anchor Load } P_{AL} = q A_p (C_{BL} + C_{GL})$$

The way the calculated load is distributed is a matter for the tent designer. If the anchoring system consists of individual anchors equally spaced around the shelter and the holding capability of the anchor is known, the total load divided by the anchor holding power will determine the number of anchors to be used. If the shelter is to be continuously held down along the floor perimeter, the total load divided by the shelter perimeter determines the load/foot.

The U.S. Army uses several types of anchoring systems such as concrete pads with metal hold down bolts, steel hold down rings on towers and arrowhead ground anchors. The arrowhead anchors, as described in MIL-A-3962A, Anchors, Ground, Arrowhead, 4", 6" and 8" with Auxiliary Equipment, are generally used for field installations. Considerable work is being done by the Natick Laboratories to determine the holding capabilities of the 4" arrowhead anchor in various types of soil. This work will be reported separately after it is completed. To give an indication of the order of magnitude of the holding power, 4" anchors, when driven to their full depth of 28" will hold about a 1000 lbs in sand and about 2000 lbs in sandy gravel.

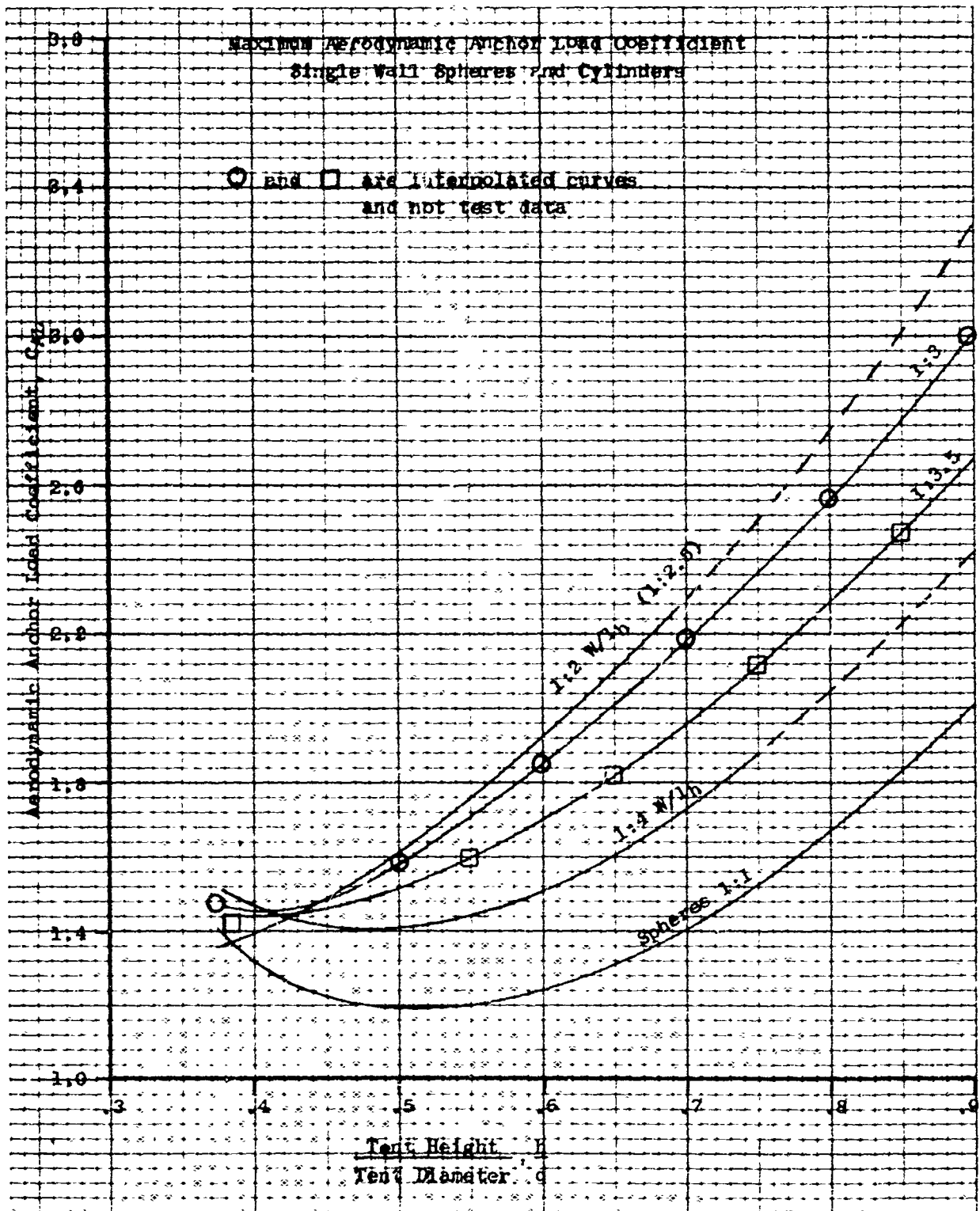


Figure 6. Variation of Anchor Load Coefficient with Shape

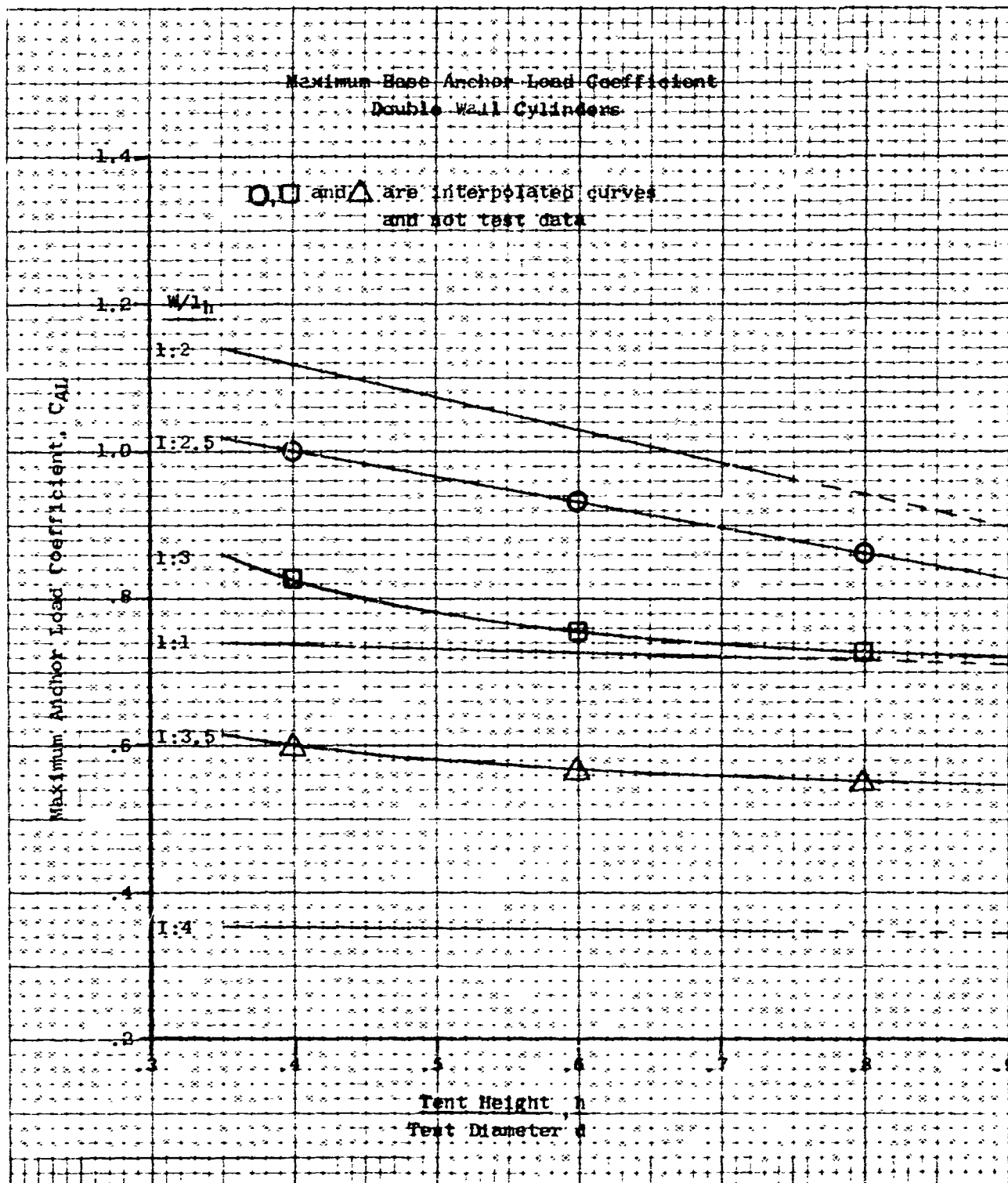


Figure 7. Variation of Base Anchor Load Coefficient-Shape

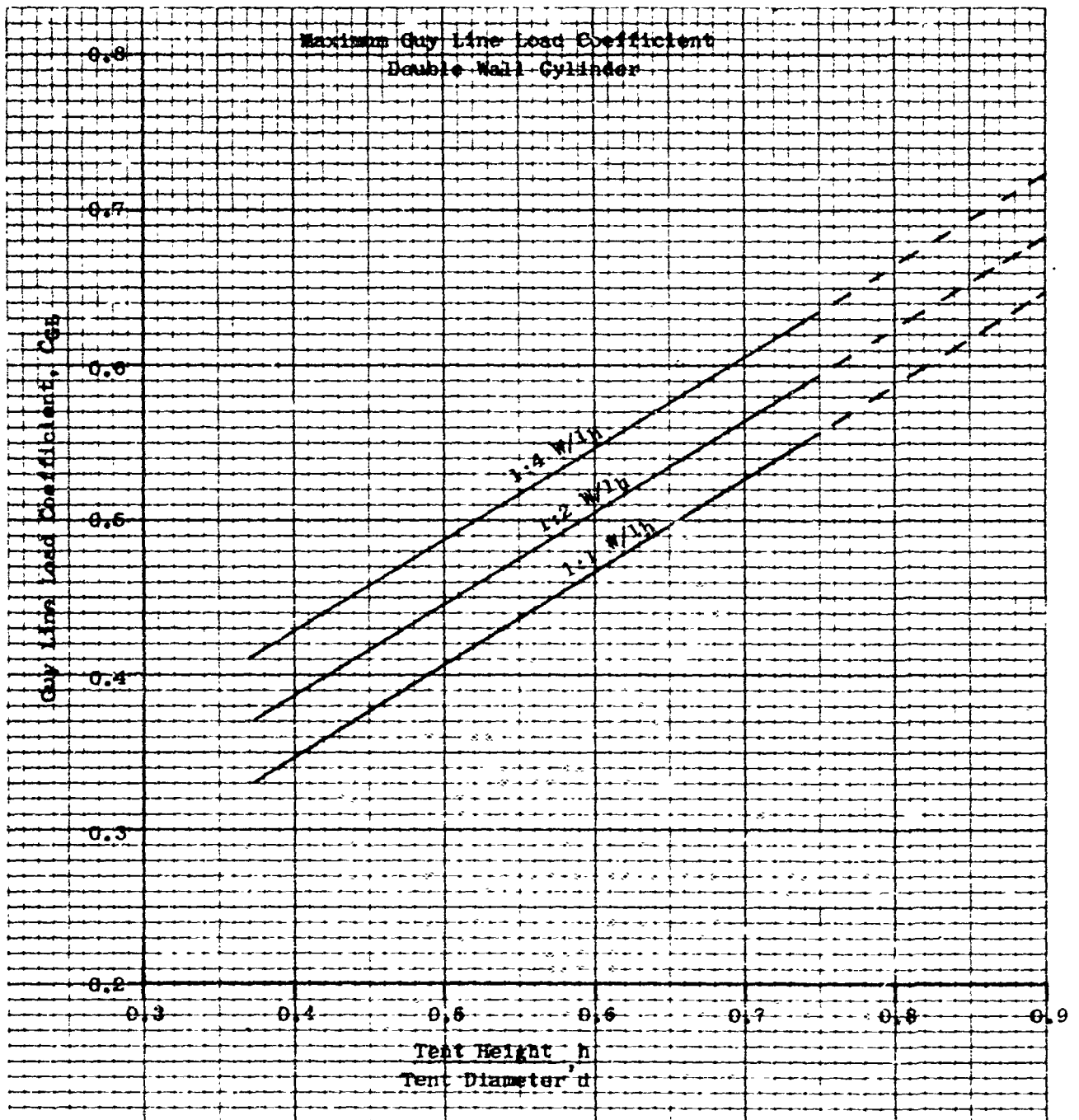


Figure 8. Variation of Guy Line Load Coefficient with Shape

Another fact of interest is that for anchors driven 28-30" the minimum distance between anchors should be at least 30 inches. These figures are presented for illustrative purposes only and will indicate the type of information required concerning the anchoring system to be used on the shelter being considered.

d. Sample Calculations

(1) The following calculations are for the single-wall, spherical shape (Fig. 9):

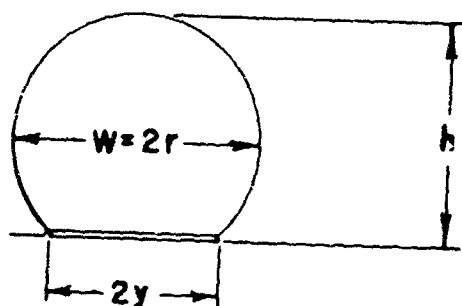


Figure 9. Single-Wall Sphere

Width = $W = 30 \text{ ft} = 2r$

Height = $h = 22.5 = \text{ft}$

Sea level

Temperature expected + 60 to -30°F

Wind velocity = 90 knots

Enclosure pressure = q

Geometric Considerations

$$\text{Length of chord} = 2y = 2\sqrt{r^2 - (h-r)^2}$$

$$y = \sqrt{2hr - h^2}$$

$$y^2 = 2(22.5)(15) - (22.5)^2 = 169$$

$$y = 13 \text{ ft}$$

$$A_f = \pi y^2 = 169\pi = 531 \text{ sq ft}$$

$$\text{Perimeter} = 2\pi y = 2\pi(13) = 82 \text{ ft}$$

$$A_p = \pi r^2 = \pi(15)^2 = 709 \text{ sq ft}$$

Determining impact pressure, q

Figure 4 - at 90 knots, q (standard) = 27 psf (lb/sq ft)

Figure 5 - max correction factor = 1.21

Actual q = 1.21 (27) = 32.7 psf

Anchor loads

Aerodynamic load

$$h/d = 22.5/30 = .75$$

$$w/l_h = 30/30 = 1.0 \text{ (sphere)}$$

Figure 6 - $C_{AL} = 1.5$

$$\begin{aligned} \text{Wind load} &= C_{AL} q A_p = 1.5 (32.7) (709) \\ &= 34,700 \text{ lbs} \end{aligned}$$

$$\begin{aligned} \text{Inflation pressure load} &= P_e A_f \\ &= (32.7) (531) \\ &= 17400 \text{ lb} \end{aligned}$$

$$\text{Total Load} = 34700 + 17400 = 52,100 \text{ lb}$$

Distributing Anchor Load

Assume an anchor holds 1500 lb

$$\text{No. of anchors} \frac{52100}{1500} = 35$$

$$\text{Anchor spacing} \frac{82}{35} = 2.34 \text{ ft}$$

(2) The following calculations are for the single-wall, cylindrical shape with spherical ends (Fig. 10):

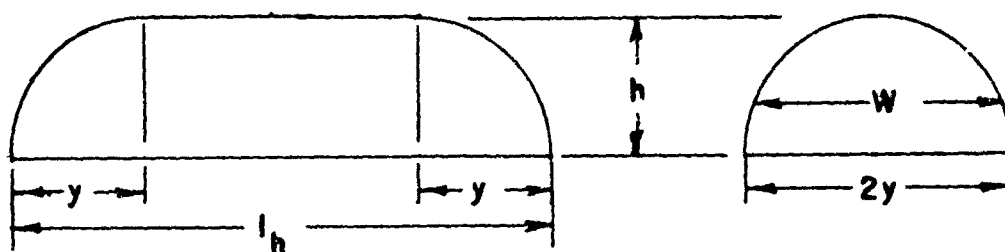


Figure 10. Single-Wall Cylinder

Width = $W = 50 \text{ ft} = 2r$

Height = $h = 25 \text{ ft}$

Length = $l_h = 100 \text{ ft}$

Sea level standard atmosphere

Wind velocity - 105 mph

Enclosure pressure = q

Geometric considerations

$$\text{Length of Chord } 2y = 2\sqrt{r^2 - (h-r)^2}$$

$$y^2 = 2hr - h^2$$

$$y^2 = 2(25)(25) - (25)^2 = 625$$

$$y = 25 \text{ ft}$$

$$A_f = \pi y^2 + 2y (l_h - 2r)$$

$$= 625\pi + 50 (100 - 50)$$

$$A_f = 1962 + 2500 = 4462 \text{ sq ft}$$

$$\text{Perimeter} = 50\pi + 100 = 256 \text{ ft}$$

$$A_p = \pi r^2 + 2r (l_h - 2r)$$

$$= 625\pi + 50 (100 - 50) = 4462 \text{ sq ft}$$

In this example the planform area equals the floor area which is not always the case.

Determining impact pressure, q

Figure 4 at 105 mph, $q = 28$ psf

Anchor loads

Aerodynamic load

$$h/d = 25/50 = .5$$

$$W/l_h = 50/100 = .5$$

Figure 6 $C_{AL} = 1.6$

$$\text{Wind load} = C_{AL} q A_p = 1.6 (28) (4462)$$

$$= 200,000 \text{ lbs}$$

$$\text{Inflation pressure load} = P_e A_f$$

$$= 28 (4462)$$

$$= 125,000 \text{ lbs}$$

$$\text{Total Load} = 200,000 + 125,000 = 325,000 \text{ lbs}$$

Distributing Anchor Load

Assume an anchor holds 2000 lbs

$$\text{No. of anchors} = \frac{325,000}{2000} = 163 \text{ anchors}$$

$$\text{Anchor spacing} = \frac{256}{163} = 1.57 \text{ ft.}$$

This spacing is quite close for a 4" arrowhead anchor system but might be suitable for other types. If arrowheads are needed, larger anchors, deeper emplacement or pairs of 4" anchors could be used to increase spacing.

(3) The following calculations are for the double-wall, cylindrical shape with flat ends (Fig. 11):

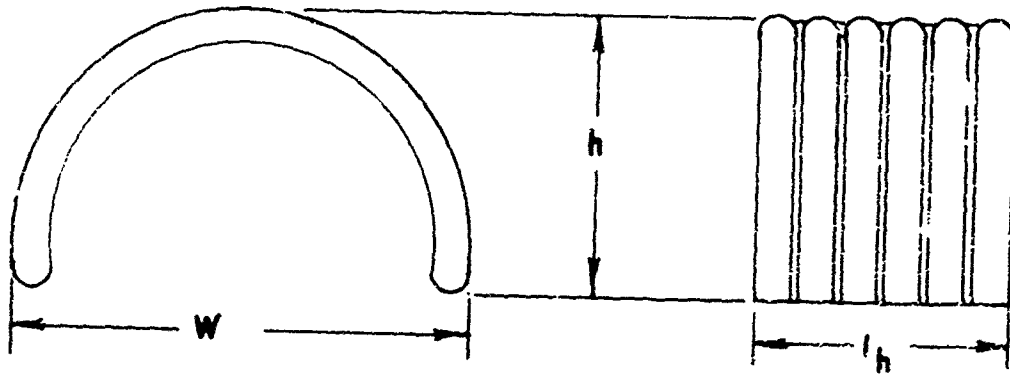


Figure 11. D-W Cylinder

Width = $W = 100$ ft

Height = $h = 50$ ft

Length = $l_h = 200$ ft

Sea level, standard atmosphere

Wind velocity -105 mph

Geometric considerations

Length of anchored sides $2(200) = 400$ ft

$A_p = W/h$

$= 100 (200) = 20000$ sq ft

Determining impact pressure, q

Figure 4 at 105 mph $q = 28$ psf

Anchor loads

$h/d = 50/100 = .5$

$W/l_h = 100/200 = .5$

Figure 7, $C_{BL} = 1.08$

Figure 8, $C_{GL} = .44$

$$\text{Total Anchor Load } P_{AL} + qA_p (C_{BL} + C_{GL})$$

$$P_{AL} = 28 (20000) (1.08 + .44)$$

$$= 856000 \text{ lbs}$$

$$BL = 1.08 (28) 20,000 = 607,000 \text{ lbs}$$

$$GL = .44 (28) 20,000 = 249,000 \text{ lbs}$$

Two points to be noted are the extreme forces possible on an air-supported structure and the fact that the base of the shelter requires three times as much anchoring as the guylines. The latter factor is contrary to common belief but has been indicated consistently in the wind tunnel studies performed on model double-wall shelters.

Distributing Anchor Loads

Assume an anchor holds 4000 lbs

$$\text{No. of Base Anchors } \frac{607000}{4000} = 152$$

$$\text{No. of Guyline Anchors } \frac{249000}{4000} = 62$$

$$\text{Spacing along base } \frac{400}{152} = 2.63 \text{ ft}$$

$$\text{Spacing of guyline } \frac{400}{62} = 6.5 \text{ ft}$$

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R&D		
(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)		
1. ORIGINATING ACTIVITY (Corporate author)		2a. REPORT SECURITY CLASSIFICATION
U.S. Army Natick Laboratories Natick, Massachusetts		Unclassified
		2b. GROUP
3. REPORT TITLE		
Guide for Estimating Maximum Anchor Loads on Air-Supported Structures		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)		
5. AUTHOR(S) (Last name, first name, initial)		
Strain, Thomas C. and Tumeinski, Ronald F.		
6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1967	18	
8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)	
b. PROJECT NO. 1M642101D503	67-54-GP	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
d.		
10. AVAILABILITY LIMITATION NOTICES		
Distribution of this report is unlimited. Release to CFSTI is authorized.		
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY
		U.S. Army Natick Laboratories Natick, Mass.
13. ABSTRACT		
<p>This report contains all the graphs, tables, mathematical formulas, and design data necessary to estimate the maximum loads on anchoring systems used with air-supported shelters subjected to winds up to 105 mph. The design data are presented in non-dimensional coefficient form. Sample problems are included to illustrate the use of the data and their application to both single and double-wall structures.</p>		

DD FORM 1473

Unclassified

Security Classification

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Data	8					
Estimation	8					
Loads (Forces)	9					
Load distributions	9					
Anchors (structural)	9					
Inflatable structures	9					
Radomes	9					
Tents	9					
Structures	9					
Air-supported	0					
Cylindrical	0					
Spherical	0					
Design manual	0					
Graphs	0					
Tables	0					

INSTRUCTIONS

1. **ORIGINATING ACTIVITY:** Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization (*corporate author*) issuing the report.

2a. **REPORT SECURITY CLASSIFICATION:** Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. **GROUP:** Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. **REPORT TITLE:** Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. **DESCRIPTIVE NOTES:** If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. **AUTHOR(S):** Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. **REPORT DATE:** Enter the date of the report as day, month, year, or month, year. If more than one date appears on the report, use date of publication.

7a. **TOTAL NUMBER OF PAGES:** The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. **NUMBER OF REFERENCES:** Enter the total number of references cited in the report.

8a. **CONTRACT OR GRANT NUMBER:** If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. **PROJECT NUMBER:** Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. **ORIGINATOR'S REPORT NUMBER(S):** Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. **OTHER REPORT NUMBER(S):** If the report has been assigned any other report numbers (*either by the originator or by the sponsor*), also enter this number(s).

10. **AVAILABILITY/LIMITATION NOTICES:** Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

- (1) "Qualified requesters may obtain copies of this report from DDC."
- (2) "Foreign announcement and dissemination of this report by DDC is not authorized."
- (3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."
- (4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."
- (5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. **SUPPLEMENTARY NOTES:** Use for additional explanatory notes.

12. **SPONSORING MILITARY ACTIVITY:** Enter the name of the departmental project office or laboratory sponsoring (*paying for*) the research and development. Include address.

13. **ABSTRACT:** Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as (TS), (S), (C), or (U).

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. **KEY WORDS:** Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.

Unclassified

Security Classification